Local dose reference levels for abdominal interventional radiology procedures

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Aims and objectives

The frequency of interventional radiology (IR) procedures has seen significant growth over the past decades. This is justified by the undisputed clinical benefits of the IR practice, the increasing clinical skills of the operators and the development of new techniques with improved X-ray systems, digital detectors, new post processing, three-dimensional imaging etc. However, IR can involve high doses to the patients. Specifically, the dose to the patients' skin can, in some cases, exceed the threshold of tissue reactions [1-3]. As a consequence, optimization of radiation protection during IR procedures is necessary.

The concept of reference levels (RL) is the main tool for the optimization of patient dose. It represents an investigational level used to identify unusually high radiation doses for common medical imaging procedures. The International Commission on Radiological Protection (ICRP) introduced this term for the first time in 90s for only diagnostic common procedures and standard size patients [4-6]. Establishing these levels on a national stage for common interventional radiology examinations is a complex task. In fact, the definition of 'common' examinations can be difficult because of the variations in patients' anatomy and pathology. Nevertheless, many international bodies focused on this topic and published guidances for establishing RL for interventional procedures [7, 8]. However, no similar national reference levels have been developed in France. In order to optimize patients' radiation protection, it is recommended to establish and use local reference levels for the most frequent and exposing procedures [9].

Jean Verdier Hospital is one of the reference hospitals in treatment of hepato-digestive diseases in France. Moreover, at present, there are still very few references in the literature about patient dosimetry in abdominal IR procedures [10, 11]. In December 2012, the radiology department of Jean Verdier Hospital has acquired a new IR interventional system with flat-panel digital detector in addition to a dose management solution, DoseWatch®. Consequently, the radiology department has implemented a quality assurance (QA) program including many processes like the training of the radiology staff in patient radiation management, standardization of all the interventional procedures labels and patient dose tracking.

In order to complete the process of QA, the purpose of the present study is to suggest initial values for local reference levels (RL) for abdominal fluoroscopically guided procedures in Jean Verdier Hospital in France.
Methods and materials

Figure 1 illustrates the method of setting up local reference levels for abdominal IR procedures. The present study focused on four of the most irradiating abdominal procedures in the interventional radiology department: hepatic embolizations (HE), gastro-intestinal embolizations (GE), Transjugular Intrahepatic Porto-Systemic Shunt (TIPSS) and Percutaneous Transhepatic Cholangiography (PTC).

Using the dose management solution, data on the fluoroscopy time, Kerma Area Product (KAP) and reference air kerma (Ka,r) were collected over a one year period.

From these records, a set of interventional RL was deduced using the 75th percentile method which is principally used for the establishment of diagnostic reference levels. This method prescribes the use of a value corresponding to the 75% of the distribution established by a dosimetric survey.

The RL values found were compared to the European and American data published in the literature.
Fig. 1: Establishment of local reference levels for abdominal interventional procedures in Jean Verdier Hospital.

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Results

99 patients were included in this study: 32 TIPSS, 24 PTC, 11 GE and 32 HE. KAP, Ka,r and fluoroscopy time distributions are given in figure 2 for TIPSS, in figure 3 for PTC, in figure 4 for GE and in figure 5 for HE procedures. The 75th percentiles are also shown on each histogram.

The suggested KAP RL deduced from the 75th percentile of the distributions are 350 Gy.cm$^2$, 41 Gy.cm$^2$, 120 Gy.cm$^2$, and 280 Gy.cm$^2$ for TIPSS, PTC, GE and HE respectively. The estimated Ka,r are 1100 mGy, 190 mGy, 430 mGy and 660 mGy and the RL for the fluoroscopy time are 54 min, 12 min, 32 min and 18 min, respectively.

In tables 1 to 3, a comparison of the proposed reference levels was done with the data published in the United States of America and Europe [10-12].

Our data are generally within the range of other reported values.

For TIPSS procedures, tables 1 to 3 show that proposed KAP RL are similar to the Swiss RL and 20% lower than the US RL. However, we can notice that the RL for Jean Verdier Hospital in terms of fluoroscopy time is 35% higher than that of the Swiss national RL. This is explained by the TIPSS procedure that is applied in our centre. In fact, unlike the procedure used generally, apart from the TIPSS placement, physicians embolize systematically the gastric varicoce veins. The latter step can be very complex and thus increases the fluoroscopy time without increasing the doses.

Indeed, the Ka,r RL of this study are 50% lower than the US RL. This can be explained by the fact that the mean weight of the American population is higher than the European population (table 4). Furthermore, it is important to note that the US reference levels were corrected for variations in patients' weight. In Jean Verdier Hospital, the range of weight for the TIPSS patients undergoing interventional procedures is 50-102 kg. The mean weight of the 99 adult subjects of this study is 71,3 kg which is conform to the standard 70 kg.

Concerning PTC procedures, our values are slightly higher compared to the published ones. While no published data were found for the Ka,r, the comparison with the Swiss RL shows 20% differences for the KAP and 37% for the fluoroscopy time.

For HE procedures, RL of this study for the three dose indicators are lower than the other values. Indeed, slight variations are found between the proposed KAP RL and the Swiss and Spanish values (6,7% and 3,1% respectively). For the fluoroscopy time, our
values are 10\% less than the Swiss RL and 26\% less than the Spanish RL. The biggest differences are noticed for the Ka,r RL where our values are 55\% lower than the US ones. This is probably owing to the difference in patients' weight between American and European states.

The largest discrepancies are found for the GE procedures. The differences between our values and the US RL amount to about 74\% for the KAP and 79\% for the Ka,r. These variations can also be explained by the high divergence in GE patients' weight between the two countries. Indeed, a difference of 33\% is noticed between the average weights (Table 4).
Fig. 2: Distribution of the KAP (Gy.cm²), Ka,r (mGy) and the fluoroscopy time (s) for the TIPSS procedure

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Fig. 3: Distribution of the KAP (Gy.cm²), Ka,r (mGy) and the fluoroscopy time (s) for the PTC procedure

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**Fig. 4:** Distribution of the KAP (Gy.cm²), Ka,r (mGy) and the fluoroscopy time (s) for the GE procedure

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**Fig. 5:** Distribution of the KAP (Gy.cm²), Ka.r (mGy) and the fluoroscopy time (s) for the HE procedure

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<table>
<thead>
<tr>
<th>Procedure</th>
<th>Jean Verdier Hospital</th>
<th>USA*</th>
<th>Switzerland**</th>
<th>Spain ***</th>
</tr>
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<tbody>
<tr>
<td>TIPSS</td>
<td>350</td>
<td>437</td>
<td>350</td>
<td>-</td>
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<tr>
<td>PTC</td>
<td>41</td>
<td>-</td>
<td>30</td>
<td>-</td>
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<tr>
<td>GE</td>
<td>120</td>
<td>463</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>HE</td>
<td>280</td>
<td>-</td>
<td>300</td>
<td>289</td>
</tr>
</tbody>
</table>

* Miller et al.
** Federal office of public heath, Notice R-06-05
*** Vano et al.
Table 1: Comparison of KAP RL (Gy.cm²) of the present study with published data
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<table>
<thead>
<tr>
<th>Procedure</th>
<th>Jean Verdier Hospital</th>
<th>USA*</th>
<th>Switzerland**</th>
<th>Spain ***</th>
</tr>
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<tr>
<td>TIPSS</td>
<td>1098</td>
<td>2162#</td>
<td>-</td>
<td>-</td>
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<tr>
<td>PTC</td>
<td>190</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>GE</td>
<td>428</td>
<td>2056#</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>HE</td>
<td>656</td>
<td>1448#</td>
<td>-</td>
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</table>

# Size corrected data
* Miller et al.
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Table 2: Comparison of Ka,r RL (mGy) RL of the present study with published data
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<table>
<thead>
<tr>
<th>Procedure</th>
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<th>USA*</th>
<th>Switzerland**</th>
<th>Spain ***</th>
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<tr>
<td>TIPSS</td>
<td>3240</td>
<td>-</td>
<td>2400</td>
<td>-</td>
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<tr>
<td>PTC</td>
<td>720</td>
<td>-</td>
<td>600</td>
<td>-</td>
</tr>
<tr>
<td>GE</td>
<td>1920</td>
<td>-</td>
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<td>-</td>
</tr>
<tr>
<td>HE</td>
<td>1080</td>
<td>-</td>
<td>1200</td>
<td>1458</td>
</tr>
</tbody>
</table>

* Miller et al.
** Federal office of public health, Notice R-06-05
*** Vano et al.

Table 3: Comparison of fluoroscopy time RL (s) of the present study with published data
### Table 4

**Comparison between the weight distribution for adult patients of Jean Verdier Hospital and the US study [11]**

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Jean Verdier Hospital</th>
<th>Miller DL et. al.</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>Mean value (kg)</td>
<td>Standard variation (kg)</td>
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<tr>
<td>PTC</td>
<td>75.1</td>
<td>12.2</td>
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<tr>
<td>HE</td>
<td>70.2</td>
<td>15.2</td>
</tr>
</tbody>
</table>

**Table 4:** Weight distribution for adult patients of Jean Verdier Hospital

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Conclusion

The establishment of reference levels in interventional radiology requires a close and continuous cooperation between the physician, the medical physicist and the radiologic technologist.

The local provisional RL values established at the Jean Verdier Hospital are comparable to those proposed by other international studies. Using the dose monitoring software, alerts will be sent to the physician and the medical physicist when dose levels exceed the defined local reference levels for each exam. In this case, investigation is initiated and data are analysed to propose corrective actions if needed.

These RL should be updated regularly in order to optimize radiation protection of patients in interventional radiology. The revision of these values and the follow up of the tendency in the next years is part of the quality assurance process implemented in the radiology department of Jean Verdier Hospital.

In the future, the percutaneous tumour ablations using 3D images will be investigated using the same method.
References


